(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

AN

(11) Publication number: **0 337 394 B1**

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication of patent specification: **12.10.94** (51) Int. Cl.5: **F04D 9/00**

(21) Application number: **89106415.6**

(22) Date of filing: **11.04.89**

(54) Method and apparatus for separating gas with a pump from a medium being pumped.

(30) Priority: **11.04.88 FI 881660**

(43) Date of publication of application:
18.10.89 Bulletin 89/42

(45) Publication of the grant of the patent:
12.10.94 Bulletin 94/41

(84) Designated Contracting States:
AT DE FR SE

(56) References cited:

FR-A- 924 306	FR-A- 1 460 397
FR-A- 2 412 726	GB-A- 648 546
GB-A- 896 366	US-A- 3 944 406

(73) Proprietor: **A. AHLSTROM CORPORATION**
SF-29600 Noormarkku (FI)

(72) Inventor: **Elonen, Jorma**
Pellervontie 7
SF-42300 Jämsänkoski (FI)
Inventor: **Timperi, Jukka**
Kasilanpolku 18 A 2
SF-48400 Kotka (FI)
Inventor: **Vesala, Reijo**
Lohniementie 29
SF-48300 Kotka (FI)
Inventor: **Wikman, Vesa**
II Piiri Riihikallio
SF-48720 Kymi (FI)

(74) Representative: **Füchsle, Klaus, Dipl.-Ing. et al**
Hoffmann, Eitle & Partner,
Patentanwälte,
Postfach 81 04 20
D-81904 München (DE)

EP 0 337 394 B1

Description

The present invention relates to a method and apparatus for separating gas with a pump from a medium being pumped respectively according to the preambles of claim 1 and 7. More precisely, the apparatus in accordance with the invention relates to the gas discharge arrangement of a pump used in the pumping of a medium containing gas. The pump in accordance with the present invention is especially suitable for pumping low, medium and high consistency fiber suspensions of the pulp and paper industry.

A method and an apparatus respectively according to the preambles of claims 1 and 7 are known from US-A-39 44 406. This document discloses a centrifugal pump for pumping liquids with a heavy gas content. An impeller is provided with ducts leading from the central inlet to the peripheral outlet of the pump, the ducts being of progressively smaller cross section from the inlet to the outlet, and openings are provided through the impeller disc for the escape of gases.

It is already well known that pumping of liquid containing gases may not be carried out at higher gas contents without gas discharge, because gases accumulate around the center of the rotor of the pump and form a bubble which grows tending to fill the whole inlet opening of the pump. This results in a considerable decrease of efficiency and vibration of the equipment and in the worst case in the interruption of the pumping. This problem seems to be especially difficult, for example, in centrifugal pumps, which have been used for decades, for example, for pumping, low consistency fiber suspensions in the wood processing industry. Various attempts have been made to solve said problems by discharging gas from the bubble. Gas is nowadays discharged in known and used apparatuses either by drawing gas with suction through a pipe, which extends to the hub of the impeller located in the center of the suction opening of the pump, by drawing it through a hollow shaft of the impeller or by arranging at least one hole in the impeller, through which hole/holes gas is drawn to the back side of the impeller and further away therefrom. All said apparatuses operate satisfactorily when the medium being pumped is liquid or the like and free from solids. Problems arise only when the medium includes solid particles, such as fibers, threads, etc. In such cases these particles risk the ducts remaining clear and open, which again is a necessity for the operation of the pump.

Of course, there are several known solutions by means of which the disadvantage and risk factors caused by the impurities are tended to be eliminated or minimized. The simplest way is probably to arrange a sufficiently large duct for the gas discharge so that clogging is out of the question. Other alternatives used are, for example, different blade wheel arrangements at the back side of the impeller. Very often radial vanes are arranged on the back surface of the impeller, the purpose of which vanes is to pump the medium, which has flowed with the gas through the gas discharge openings of the impeller to the outer rim of the impeller and from its clearance back to the liquid flow. The ultimate purpose of the vanes behind the impeller is to balance the axial forces of the pump, which is considered to be carried out best, when the amount of the rear vanes is similar to that of the actual pumping vanes. In some cases a separate arrangement is used having the same purpose as the above mentioned, but which is mounted further behind the impeller by means of a blade wheel mounted on the shaft of the impeller. Said blade wheel rotates in its own chamber tending to separate the liquid flowing with the gas to the outer rim of the chamber the gas being thus able to be drawn by suction from the inner rim of the chamber. The medium with the impurities accumulated on the outer rim of the chamber is guided via a separate duct either to the suction or discharge side of the pump. All disclosed apparatuses operate satisfactorily only when a limited amount of impurities is included in the liquid. It is also possible to adjust said apparatuses to operate relatively reliably also with liquids containing plenty of solids, for example, fiber suspensions of the pulp industry. In that case it is, however, necessary to yield in the gas discharge ability, since the main purpose is to ensure that no or hardly any fibers drift to the gas discharge duct or to the vacuum pump possibly communicating with it. Thus gaseous fiber suspension is, as a precaution, fed back to the flow. On the other hand, it is known that the gas in the fiber suspension is a negative factor in the pulp treatment process, which factor should be eliminated as well as possible. It is a waste of the existing advantages to feed the once-separated gas back to the pulp circulation. It is also a waste of pulp to separate all the pulp flowed with the gas from the pulp circulation by discharging it as a secondary flow of the pump.

The object of the present invention is thus to utilize most efficiently the capability of a centrifugal pump to separate gas from liquid, which gas is discharged from the pump itself by the simplest and operationally proof means. The only precondition is to be able to operate without a risk of the impurities flowing with the liquid, i.e. solids, such as threads, fibers, etc., being able to clog the gas discharge system.

This object is solved by a method and an apparatus respectively according to claim 1 and claim 7.

The pending Finnish application 872967 discloses some methods by which it may be ensured that, even if the material to be pumped were fiber suspensions of the pulp and paper industry, the fibers of the suspension cannot clog the gas discharge system or the vacuum pump communicating with it. In said application a filter surface or the like is arranged in the flow passage of the gas being discharged prior to the vacuum pump possibly used in the process, by which surface the fibers of the suspension are prevented from entering the gas discharge system.

On the other hand, also US-A-4,673,330 discloses a method of controlling the operation of a centrifugal pump in such a way that the pump is dimensioned to the desired lift height and capacity by adjusting the size of the gas bubble generating in front of the pump.

The arrangement in accordance with said publication comprises a plurality of electric sensors arranged radially on the housing of the pump behind the impeller on the rear wall, which sensors measure the size of the gas bubble generating between the impeller and said rear wall on the basis of the varying ability of liquid and gas to conduct electricity or the like ability.

It is noted in said publication that neither the medium between the back vanes of the impeller nor the gas bubble inside the medium are evenly round, but the boundary surface between them is to some extent serrate in such a way that each back vane in a way pushes the medium layer in front of it and the medium layer tends to move towards the outer rim due to the centrifugal force. However, for a reason not explained in the publication the portion of the medium which is on the surface of such pushing vane is closest to the center of the impeller. Such regularity prevails not only with the actual pumping vanes, but also with the so called rear vanes radially arranged behind the impeller according to the publication.

According to our invention and due to the fact that the factors resulting in the wavy form of the boundary surface between gas and said pulp in the previously described publication has been succeeded to explain thoroughly, it has become possible to define the dimensions of the rear vanes of the impeller and their location, the size and location of the gas discharge openings piercing the impeller and the dimensions of the central opening of the rear wall behind the impeller of the pump and the mutual dimensions of the above described parts in such a way that the discharge of gas from the centrifugal pump is possible without the above mentioned screen plate arrangement or also the above described guiding means of the pump based on electric sensors, which means could be used, by all means, also merely for adjusting the size of the gas bubble.

The basic principles of the arrangement in accordance with the present invention are following:

- the smallest radial measurement of the part of the gas bubble generating in the centre of the pump, which part is on the back side of the impeller, has to be larger in all operating conditions than the radius of the central opening in the rear wall of the pump, so as not to allow any movable solid particles flowing with the medium to enter the gas discharge system;
- the highest radial measurement of the part of the gas bubble on the back side has to be in all operating conditions smaller than the radius of the impeller, so as not to allow the gas to flow back to the medium being pumped;
- the distance of the perforations for the gas discharge from the axial line of the pump has to be longer than the radius of the opening in the rear wall, so as not to allow any solid particles possibly flowing with the gas directly to be discharged into the gas discharge system.

Additionally, due to the serrated form of the gas bubble mentioned above the radial dimension of the medium layer in each gap between the back vanes has to be taken into consideration. In the worst case the above described conditions cannot be fulfilled, because the medium resting against the surface of the pushing vane may extend to the level of the opening of the rear wall and, on the other hand, the outermost part of the gas bubble may at the same time extend to the rim of the impeller. Thus a situation is reached, in which the opening of the rear wall has to be as small as possible, the limit being the size of the diameter of the shaft. On the other hand, the diameter of the impeller has to be made as large as possible, the dimensions of the rest of the pump set the limit for it to a certain easily determined limit value. Also considering the different operating conditions of the pump, the variety of rotational speeds being used in different conditions and the media having different gas contents, the point will be reached at which the distance of the ultimate radial measurements of the gas bubble should be diminished as much as possible.

In addition to that, although the publications of the prior art disclose a great number of arrangements for the location of the gas discharge openings in the rear plate of the impeller, no proper instruction or arrangement has been found. CH-P-571655 gives an example of an arrangement in which perforations have been arranged adjacent to the rear surface of the vane at variable radial distances from the shaft of the pump, the diameter

of perforations diminishing outwards from the shaft. In the so called first generation MC- pumps the gas discharge opening for the medium consistency pulp have been arranged as oblong openings (Fig.2), which are located between the vanes of the impeller and extending almost from one vane to another at a similar radial distance from the shaft of the impeller. Thus the positioning of the gas discharge openings has been until today more or less accidental without any theoretical or even profound experimental definition.

The present invention is based on the fact that the dimension and the position of the rear plate of the impeller and the rear vanes in it and the dimensions of the rear wall of the pump have been optimized and that the form of the boundary surface between the gas bubble and the liquid ring surrounding the bubble has been balanced to such an extent that in practice no or hardly any medium being pumped enters the gas discharge system with the gas.

The following list gives examples of the advantages of the centrifugal pump according to the present invention in comparison with the existing arrangements:

- more effective discharge of gas, because it is not necessary to return gaseous liquid to the main circulation;
- in the pumping of fiber suspensions there is no risk of clogging the gas discharge ducts or the pulp being wasted or drifted to the sewage;
- the construction of the unit being used in the pumping becomes simpler, the use becomes more reliable, and the running costs reduce, because a vacuum pump does not necessarily require a separate driving motor;
- it becomes possible to pump pulps with considerably higher consistencies, because the high content of air in high consistency pulps has with the prior art arrangments prevented the pumping.

The method and apparatus in accordance with the present invention may be applied to the conventional centrifugal pumps, whereby it is, of course, necessary to compromise with the consistency of the pulp being pumped, but also to MC-pumps in accordance with the prior art, whereby it is possible with these pumps provided with rotors extending to the suction opening to treat considerably thicker pulps than before.

The apparatus in accordance with the present invention and the method used with it are described below, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 is a sectional side view of a centrifugal pump in accordance with the prior art technique and its gas discharge system;

Fig. 2 is a schematic back view of an impeller of a centrifugal pump in accordance with the prior art;

Fig. 3 is a schematic back view of an impeller of a centrifugal pump in accordance with an embodiment of the present invention;

Fig. 4 is a schematic back view of an impeller of a centrifugal pump in accordance with a second embodiment of the present invention;

Fig. 5 is a schematic back view of an impeller of the centrifugal pump in accordance with a third embodiment of the present invention;

Fig. 6 is a schematic view of arrangements in accordance with some other embodiments combined together in one drawing seen from the back side of the impeller; and

Figs. 7a and 7b visualize the forces affecting each pulp particle behind the impeller.

The so called first generation centrifugal pump for medium consistency fiber suspensions (so called MC-pump) in accordance with Fig.1, which is described more in detail, for example, in US-A-4410337, mainly comprises in principle following elements: a housing 1 of the pump, a suction opening 2 therein, a discharge or so-called pressure opening 3, a shaft 4 of the pump, an impeller 5 provided with pumping vanes 6 and mounted on the shaft, a rear plate 7 of the impeller, a rear wall 8 of the pump and a gas discharge conduit 9. Gas discharge openings 10 of impeller 5 described in the figure are located in close proximity to the shaft 4 of the pump, because thus one has tried to ensure that no or hardly any fibrous liquid is allowed to enter the gas discharge system. So called rear vanes 11 have been arranged radially to the back side of the rear plate 7 of the impeller, and they have two purposes in this type of a pump. On one hand, they equalize the axial forces in the pump and, on the other hand, they are also used for pumping the liquid, which has flowed behind the rear plate, back to the main flow towards the pressure opening 3. Corresponding to the openings 10 of the impeller, an annular duct 12 has been maintained around the shaft in the rear wall of the pump, through which duct the gas is discharged to the space 13 on the back side of the rear wall 8, from which space the gas discharge conduit 9 leads the gas further, most usually through a separate vacuum pump away from the pump.

Fig. 2 illustrates a back view of the impeller 5 used in reality in the arrangement in accordance with said US patent. As can be seen, the number of the so called rear vanes 11 on the back side of the impeller is six, which amount has become established. Also, the aim has generally been to minimize the amount of the rear vanes, but in the end the number has been settled to six, because also the number of the actual pumping vanes on

the opposite side of the impeller in the arrangement is in practical arrangements six. Furthermore, said rear vanes 11 have always been in the prior art arrangements radial so as to simplify the manufacture and because no reason for their directing otherwise has come about. The figure also illustrates the construction and the location of the gas discharge openings 10, in other words, the openings are oblong and curved parallel to the rim of the impeller being therefore constantly at the equal distance from the axis of the pump. The figure also illustrates the annular duct 12 remaining between the rear wall of the pump and the shaft of the impeller, through which duct gas flows into the gas discharge system.

Additionally, an arrow A shows in Fig.2 the rotational direction of the impeller and the boundary surface between an air bubble on the back side of the impeller and the fiber suspension surrounding it is sketched by a broken line 14, which boundary surface forms the serrate figure described already in connection with the prior art technique. It should be noted that the form of the gas discharge openings with the constant radial distance is not the best possible, because a corresponding serrate figure is formed also on the opposite, the actual pumping side of the impeller. Therefore, it may be stated that, although the part of the gas discharge opening, close to the back side of the pumping vane very efficiently allows the flow of the gas from the front side of the impeller to the back side, the opposite end of the gas discharge opening is in the fiber suspension zone, whereby some of the fiber suspension flows to the back side of the impeller, which alone is undesirable. On the other hand, it is noted that the radial dimension of the gas bubble is at its greatest very close to the outer edge of the impeller, so if gas is not efficiently enough drawn away from said space, there is a risk that the gas bubble begins to be discharged back to the main flow from the outer rim of the impeller. If such a situation were encountered in practice, compromises should be made in the gas discharge ability of the pump, because there is also the counterrisk that, if the suction effect of the vacuum pump drawing gas is increased, fiber suspension enters gas discharge system through the annular gap between the rear wall of the pump and the shaft, whereby the liquid ring pump operating most usually as the vacuum pump might clog almost immediately and might result in both service and possibly also reparation operations.

The main reasons for the formation of the described serrate figure are described below. When the pulp is discharged through the openings of the impeller to the back side of the impeller, said pulp has a rotational speed substantially corresponding to the circumferential speed of said openings. The pulp is subjected on the back side of the opening to a centrifugal force, which tends to throw the pulp outwards, whereby the motional direction of the pulp due to the inertia tends to be, not radial, but curved backwards relative to the movement of the impeller. In other words, the pulp tends to maintain the same circumferential speed which it had when being discharged through the opening, regardless of the fact that it constantly moves outwards towards the rim, whereby the impeller tends to "pass" the pulp due to the continuously increasing difference in the circumferential speeds. Thereby, the pulp, when moving outwards, flows to the surface of the rear vane next to the opening, which rear vane accelerates the circumferential speed of the pulp. Because new pulp constantly accumulates along the surface of the rear vane outwards towards the rim of the impeller, the part of the pulp, the circumferential speed of which has become higher, must move forwards parallel to the rim towards the rear surface of the preceding vane, whereby a more or less inclined boundary surface between pulp and gas is formed to each vane gap. In addition to said circumferential speed and centrifugal force, there is a force affecting the pulp between the vanes, which force is due to the pressure changes in the volute of the pump and which is varying in intensity and is directed towards the axis of the pump. Said force, according, to the description, tends to push the pulp towards the axis of the pump and more precisely tends to press the pulp through the central opening in the rear wall of the pump to the gas discharge system. It is a known fact that when the volute of the pump is of spiral form, the pressure is at its highest substantially at the discharge opening of the pump, from where onwards it relatively evenly diminishes when moving against the rotational direction of the impeller, and being at its lowest in the part of the volute immediately following the discharge opening in the rotational direction.

Fig.3 illustrates a back view of an impeller arrangement 5 of the pump in accordance with an embodiment of the present invention and corresponding to Fig.2. First of all, it is noted in the figure that the number of rear vanes 11 has been increased. The reason for that is that by operating this way it is possible to make the serrate form of the boundary surface between the gas bubble and the fiber suspension considerably more even. In a way the peaks in both direction have been cut off. An explanation for this lies in that, because there are several rear vanes 11, the centrifugal force together with the inertial force is not able to spread the boundary surface between the fiber suspension and the gas bubble radially to a very large area. When the radial forces caused by the pressure

changes of the guiding apparatus 15 and their effects are also taken into consideration in this embodiment, it can be maintained that by increasing the number of the rear vanes 11 the sectors become narrower and the effective time of a pressure peak on the pulp in one single sector diminishes and the number of sectors being sufficient so that an intensive pressure stroke has no time to accelerate the kinetic speed of the pulp towards the shaft to the extent that the pulp flows to the gas discharge opening 12 in the rear wall 8 of the pump, but when the impeller 5 rotates forwards said sector reaches the low pressure zone, whereby the centrifugal force tends to move pulp back towards the outer rim of the impeller.

Thus this change alone ensures that gas does not easily flow back to the main flow of the suspension, although a considerably modest underpressure might be used in the gas discharge system. On the other hand, the use of a considerably high underpressure either cannot generate the flow of liquid from the front side of the impeller of the pump through the gas discharge openings to the back side of the impeller or, correspondingly, from the back side of the impeller, to the gas discharge system. It is, of course, possible in practice to use also so high underpressure that fibers enter the gas discharge system, but this would require a considerably overdimensioned underpressure with the apparatus in accordance with the present invention. The real advantage of the invention is that a pump provided with an impeller in accordance with the present invention operates more reliably in changing operating conditions, because the boundary surface between the gas bubble and the liquid ring is at each point farther from both the outer edge of the impeller and the gas discharge opening or the central opening in the rear wall of the pump. Thus the present invention has brought about a considerable margin for the different risk factors.

Furthermore, the operation of the gas discharge system of the pump may be facilitated by locating the gas discharge openings 20 in impeller 5 at exactly right positions. Most advantageously gas discharge opening 20, of course, has to be located to each vane gap of the pumping side of impeller 5 or to each space between the lines drawn from the inner edge of each pumping vane 6 (shown with broken lines) to the axial line of impeller 5. It was already noted above that the oblong gas discharge opening (10; Fig.2) of the MC-pump in accordance with the prior art does not have a very advantageous form for the reason already mentioned above and is not advantageously located, either. Openings 20 are most optimally located and formed when the form of the edge on the side of the boundary surface between the gas bubble and the liquid ring follows the form of the boundary surface (14; Fig.2) and is nevertheless located as far from said boundary surface as possible. This results in the gas discharge openings 20 shown in Fig.3, which are substantially triangular and are located in this case on the suction side of every other rear vane 11, in other words relative to the rotational direction to the back side of vane 11. The figure illustrates two rear vanes 11 for each pumping vane 6 of impeller 5 and yet in such a way that every other rear vane 11 is located at least partly at the pumping vane 6. If the gas discharge openings 20 have the form shown in the figure and are located at the position shown in the figure it is possible to change the position of the gas discharge openings 20 slightly further out on the impeller 5 so as to gain more safety margin between the radial distances of the central opening 12 of the rear wall 8 of the pump and the gas discharge opening 20. Yet, it must be born in mind that the described triangular form is only a preferred embodiment and it is, of course, possible that the openings are, for example, round perforations or that the openings are formed by several possibly round perforations.

An embodiment worth mentioning is in which the rear vanes 21 are inclined to a slightly more pumping direction, shown in Fig.4, in other words vanes 21 are inclined in a way backwards around the point at the end closest to the shaft, whereby the vanes subject the material being pumped to a motional component parallel to the rim and in addition to that also to a component intensifying the effect of the radial centrifugal force directed outwards by which component it is possible to move the boundary surface between the gas bubble and the liquid ring located on the surface of rear vane 21 of impeller 5 further on, whereby the form of the boundary surface becomes even more even. Additionally, the inclination of the vanes effects the increase in the length of the distance which the pulp should flow during the effective time of a force component caused by a pressure peak of the volute 15 and directed towards the shaft in order to manage to reach the gas discharge duct 12 of the rear wall of the pump. This further ensures that the pulp has no time to reach the gas discharge opening 12 before the pressure in the volute 15 has decreased rapidly to its minimum, whereby the centrifugal force rapidly becomes superior to the movement towards the axis caused by the inertia of the pulp and begins to move the pulp back towards the volute. By using inclined rear vanes 21 it is possible to decrease the number of rear vanes compared with the previous embodiment, because the same reliability is gained with a smaller number of vanes. On the other hand, it is also possible to incline the rear vanes forwards to some extent,

whereby a corresponding combined effect of forces, in other words the effect decelerating the flows of the pulp is gained.

The performed experiments prove right the basic idea of the above described theory that by inclining the vanes it is possible to decrease their number and also that the increase in the rotational speed of the impeller also decreases the number of the vanes required. The vane frequency required with straight radial vanes has been determined in experiments to about 370 Hz (number of vanes * rotational speed of the impeller r/s), so as not to let the pulp flow to the gas discharge system. If the vanes are inclined, it is possible to count the number of vanes by the following formula:

$$z * n / \sin\beta > 370,$$

in which

- $\underline{z}$ is the number of vanes as an integer,
- $\underline{n}$ is the rotational speed of the impeller in r/s,

and

- $\underline{\beta}$ is the angle between the average direction of the rear vane and the tangent, of the rim of the impeller. Thus the number of vanes gained is

$$z > 370 * \sin\beta/n,$$

so, for example, when the angle β is 45° and the rotational speed n about 50 r/s, this results in that the required number of vanes is at least 6, whereas with straight vanes the angle β being 90° the formula results in 8 as the number of vanes.

Yet another embodiment is illustrated in Fig.5, which has two rear vanes 31 and 32 for each front or working vane 6. According to the figure the rear vanes are all inclined backwards as already in the previous figure, additionally the rear vanes are curved and vane 31 following gas discharge opening 20 in the rotational direction is of full length extending from the outer edge of gas discharge opening 12 in the rear wall of the pump to the outer edge of impeller 5, whereas in the rotational direction vane 32 precedes the gas discharge opening 20 in the impeller 5 substantially extends from the rim formed by the edges of said gas discharge openings 20 closest to the shaft to the outer edge of impeller 5. Naturally, it is possible that the dimensions of said vanes 31, 32 deviate even to a considerable extent from the dimensions of the above described preferred embodiment yet not deviating from the inventive concept and the operational pattern being described below.

Fig. 5 visualizes how the pulp accumulated in the vane gaps 33-38 from gas discharge openings 20 of the impeller behaves firstly at different points of volute 15 and additionally in vane gaps 33-38; 39-44, which are in principle of two types. The pulp in vane gaps 33-36 on the front side of the full-length vane 31 acts as already roughly described above. In other words, almost in all vane gaps 33-38 the boundary surface between the pulp and the gas forms a serrate figure in such a way that the pulp against the front surface of the full-length vane 31 is closer to the shaft than the part of the pulp which is against the rear surface of the preceding shorter vane 32. However, in vane gaps 37 and 38, namely in those gaps, which are affected by the highest pressure of volute 15, which pressure has made the pulp to flow towards the shaft, in those gaps the direction of the boundary surface between the pulp and the gas is first turning (vane gap 37) and then has already turned to the opposite direction (vane gap 38). This is explained by the fact that the pulp in vane gap 37 has reached a certain circumferential speed, which it tends to maintain due to its inertia regardless of the fact that when the vane gap is moving to the zone of higher pressure this causes the pulp to move towards the center, whereby the circumferential speed of the impeller 5 relative to the speed of the pulp parallel to the rim decreases and the pulp accumulates against the rear surface of the shorter vane 32 operating as the front surface of vane gap 38. Thus said boundary surface extends in vane gap 38 of Fig.5 already over gas discharge opening 20 of impeller 5 and gradually said boundary surface extends to the inner edge of the shorter vane 32, from where the flow still due to its inertia is discharged to the preceding vane gap 44, in which the centrifugal force throws the pulp towards the outer rim. A lower pressure of volute 15 prevails also in the preceding vane gap 44, because it has already moved past the high pressure zone. At this stage the shape of the boundary surface between the pulp and the gas must also be noted in vane gaps 39-44, in other words in those vane gaps which have no gas discharge opening 20 of impeller 5. Said shape remains substantially parallel to the rim of impeller 5 all the time, because the changes of the circumferential speed of the pulp in said gaps 39-44 are minor and also the radial movements of the pulp in said vane gaps are relatively small.

Other possible embodiments are arrangements shown in Fig.6, used either together or, especially, separately. First alternatives for eliminating the pressure effects of volute 15 that come into question are, of course, both sealing of the outer edge of impeller 5, for example, by arranging the clearance between impeller 5 and the housing of the pump by a closing element 50 so small in such a way that the pressure of volute 15 would not affect disadvantageously to the back side of impeller 5, when the pressure is otherwise at its highest, and

arranging the clearance between the rear wall of the pump and the shaft by a corresponding closing element 51 respectively so small that the radial flow of the pulp decelerates in the vane gap at the pressure peak when the vanes are, for example, of the type shown in Fig.3.

Furthermore, it might be possible to design the rear vanes of impeller 5 in such a way that the radially inwardly directed movement of the pulp due to said pressure is prevented, for example, by bending the inner ends of the shorter vanes 52 to follow the shape of the edge of opening 20 of impeller 5, whereby the pulp flowing along the rear surface of said vane 52 towards the axis is forced to be discharged through said opening 20 to the front side of impeller 5 when the gas is correspondingly discharged through the clearance between the shorter and the longer vane towards the gas discharge opening 12 in the rear wall of the pump. It is, of course, not necessary that in the last mentioned embodiment the vanes were of different length or that there were two vanes for each pumping vane 6, whereby the inner edge of each rear vane is bent in the described manner. Further, it is possible to arrange rear vanes, which in this case were equally long, slightly shorter than what is described above in such a way that when the fiber suspension moves towards gas discharge opening 12 it may flow to the preceding vane gap without a risk of the pulp escaping through the gas discharge opening in the rear wall of the pump to the gas discharge system.

Fig. 6 illustrates also a few other alternatives for the gas discharge openings of the impeller. It is, of course, possible that the openings are either separate round perforations 54 or a group of perforations 55 or even a great number of perforations, whereby in a way a filter surface is formed in the gas discharge opening.

Further, it is possible to arrange a discharge opening 56, for example, to each rear vane of the impeller moving in the rotational direction in front of a vane gap having a gas discharge opening 20 through which discharge opening 56 the pulp flowing due to the pressure in the volute towards the axis may be discharged to the preceding vane gap. Said discharge opening may be a perforation 56, or a slot in the vane, a bevel in the area of one end of the vane, it may be an opening between the vane and the rear plate of the impeller or it may also be an actual break in the vane. One possibility, which, of course, comes into consideration is to arrange a discharge cut-out or even a flow duct in the rear wall of the pump in the area of rear vanes and further to the area in which the higher pressure of the volute may influence the vane gaps, in other words between the center of the pump and the discharge opening. In all described arrangements the pressure of the volute may be discharged to the vane gap/gaps next to it or even to some other vane gap (through the duct in the rear wall of the pump), which vane gap is in the area of the lower, or if the whole pressure field of the guiding apparatus is considered, the lowest pressure. It is, of course, possible to arrange a corresponding flow passage 57 into communication with the other vane 53, in other words the one being further behind in the rotational direction, which vane also limits the vane gap, whereby the pressure would be discharged in a corresponding way to the vane gap next to it, but the operational concept of this is not as elegant as the above described solution.

In addition to the emodiments discussed above, a few other alternative arrangements may be mentioned, which are not shown in the drawings. Firstly, as mentioned already above, the clearance between the impeller and the housing of the pump may be arranged small in the area of the rear vanes in such a way that the curved plate shown in Fig. 6 is extended to cover the whole length of the rim, whereby the rear vanes of the impeller rotate inside their own ring, in which ring openings have been arranged for the discharge of the material accumulated in the vane gaps to the volute of the pump. When said perforations are positioned mainly in the area of the lower pressure of the volute, the pressure of the guiding apparatus is not able to affect the pulp in the vane gaps.

It may also be considered that the effect of the pressure of the volute may be diminished by decreasing the time, which the force component caused by the pressure of the guiding apparatus towards the center uses to accelerate the pulp in the vane gaps or by increasing the distance the medium must flow to reach the gas discharge duct. The first attempt to this is, of course, the above mentioned increase of the number of the vanes, but there are also other methods. Firstly, it is possible, for example, to bend strongly the outer ends of the vanes or the outer end of at least one of the vanes limiting each vane gap provided with a gas discharge opening of the impeller towards the other vane limiting said vane gap in such a way that the dimension of the part of said vane gap open in the outer rim, which dimension is parallel to the rim, diminishes, whereby the effective time of the above mentioned force component naturally diminishes. Bending of the vane/vanes may be arranged, for example, in such a way that the top part of the vane is extended parallel to the rim towards another vane or that the vane as a whole is bent more towards another vane. Thereby the component towards the shaft caused by the pressure of the guiding apparatus creates a radial force directly affecting to the impeller. It is, of course, also possible that the vanes are arranged, for example, in

such a way that every other one is radial and the rest are bent backwards, whereby the vane gap either remains equally broad in the direction of the rim or it may even become narrower outwards. Further, it is possible to arrange one or more local constriction points between the rear vanes or to arrange the form of the rear vanes wavy in such a way that the distance which the flow runs from the outer rim of the impeller to the gas discharge duct becomes longer, whereby also the decelerating effect of the frictional forces on the movement of the pulp increases.

Figs. 7 a and b yet visualize the forces affecting each pulp particle which has flowed to the back side of the impeller through the gas discharge openings of the impeller. Fig. 7 a illustrates a situation, in which the pulp particle has just flowed through said opening to the back side of the impeller, in other words, a situation, in which the centrifugal force mainly determines the motional direction of the pulp particle, which is thus towards the rim of the impeller. Fig. 7 b illustrates a situation, in which the pulp particle is subjected to a so intensive radial force from the direction of the rim that also the particle moves towards the axis of the impeller. In the figures different forces are referred to in the following way:

Fc = centrifugal force, Fi = inertial force, Fsp = radial force, which is due to the pressure of the volute, Fb = force directed to the pulp particle from the rear vane. Additionally, the subindexes r and c refer to the radial component and the component parallel to the rim. Furthermore, the direction of the resultant R of said forces has been roughly sketched to the drawings and the resultant may in reality deviate even considerably in size and in direction from the above described.

According to Fig. 7a, in a centrifugal pump, to which the arrangement in accordance with the present invention may be applied, the pulp particle is subjected to a centrifugal force directed away from the axis and to a force, which is due to the pressure of the volute of the pump directed towards the axis, but which force is, however, less intensive than the centrifugal force. In addition to that, the particle is affected by an inertial force, which due to the combined effect of said radial forces has in the figure the shown direction, in other words decelerating the movement of the pulp particle relative to the impeller.

Furthermore, the pulp particle is subjected to two force components, one radial and the other parallel to the rim, by the rear vane of the impeller in this case the rear vane being inclined, whereby the resultant R of the forces directed to the pulp particle has the direction of the tangent of the vane of the impeller.

In Fig. 7b the pulp particle is subjected to a powerful force towards the axis, which is due to the pressure of the volute, in such a way that the force even becomes superior to the centrifugal force. Thereby the inertial force tends to carry the pulp particle faster than the impeller in the direction following the rim, which effect is resisted by the rear surface of the rear vane in such a way that the direction of the resultant of all forces is parallel to the tangent of the rear vane. This figure especially clearly indicates the fact, what happens, when the force directed to the pulp particle by the rear vane ceases. In this case the force effect directed towards the axis diminishes and the force effect parallel to the rim increases, whereby the direction of movement of the pulp particle changes and approaches the direction of the tangent of the rim. In other words, if the effect of the rear vane ceases prior to the central gas discharge opening of the rear wall of the pump, the direction of the pulp particle changes around the end of the vane, whereby the pulp particle is forced to the previous vane gap, in which on one hand the pressure effect of the volute is at its weakest and on the other hand the effect in accordance with Fig. 7a is at its highest.

As it is noted in the above description, a great number of arrangements has been developed, by which it is possible reliably to prevent the fiber suspension from flowing to the gas discharge system and in the vacuum pump in it. In the earlier arrangements it has been necessary for the above mentioned reason to arrange the vacuum pump to be run by a separate drive unit such as an apparatus outside the pump. However, now the present invention has brought about the possibility to use a vacuum pump in connection with the pumps used for pumping fiber suspension, an example being a so called liquid ring pump, to be used directly with the pump by the same drive unit. In other words, a vacuum pump may be arranged on the same shaft inside the housing of the centrifugal pump without a risk of clogging the vacuum pump and of troublesome reparations.

Claims

1. A method of separating gas from a gas-containing medium being pumped in a pump which comprises a housing, an impeller arranged in the housing and having pumping vanes, rear vanes and gas discharge openings, and a gas discharge system in the housing, comprising the steps of:
   - separating the gas from the medium at the front side of the impeller,
   - discharging the separated gas through the impeller via the gas discharge open-

ings to the rear side of the impeller,
- discharging the medium which has possibly passed together with the gas to the rear side of the impeller from the gas by means of the rear vanes, and
- discharging the gas from the pump via a gas discharge duct in the housing leading to the gas discharge system,

characterized by
- establishing the boundary surface between the medium and the gas in the space behind the impeller generated by the combined effect of radial forces, forces parallel to the rim of the impeller and inertial forces between a smallest and largest radial limit, the smallest radial limit being larger than the radius of the gas discharge duct and the larger radial limit being smaller than the radius of the impeller.

2. A method according to claim 1, characterized by directing the flow along the back-surface of a rear vane of the impeller towards the axis of the impeller by means of the combined effect of the forces and allowing the flow to be discharged into a vane gap preceding the rear vane in the rotational direction of the impeller by the guidance of the component of force which is parallel to the rim.

3. A method according to claim 1, characterized by directing the flow of the medium flowing towards the impeller axis by means of the combined effect of the forces, towards the gas discharge openings in the impeller, and allowing the flow to be discharged to the front side of the impeller through the gas discharge openings.

4. A method according to claim 1, characterized by preventing the pressure of a volute of the pump from entering the space and acting on on the medium, when the pressure of the volute is at a point adjacent to its maximum, by throttling the flow passage at the corresponding point.

5. A method according to claim 1, characterized by preventing the entrance into the gas discharge duct of the flow of the medium flowing towards the impeller axis and generated by the pressure peak of a volute of the pump, by throttling the flow passage leading to the gas discharge duct at the position of the peak pressure of the volute.

6. A method according to claim 1, characterized by preventing the pressure peak of a volute of the pump in a vane gap between the rear vanes from accelerating the medium in a direction towards the gas discharge duct by directing the discharge of the pressure around the edge of a rear vane preceding the vane gap in the rotational direction of the impeller or via an opening, slot or the like in the preceding rear vane into a vane gap or gaps next to the said former gap.

7. An apparatus for separating a gas from a gas-containing medium being pumped by a pump, which pump comprises a housing (1) with suction and discharge openings (2, 3), an impeller (5) arranged inside the housing and provided with pumping vanes (6), rear vanes and gas discharge openings, a rear wall (8) of the pump, and means for the discharge of the gas from the pump including a gas discharge duct (12) in the rear wall (8), characterized in that the rear vanes (11; 21; 31, 32; 52, 53) and the members operating together with them are arranged such that a boundary surface between the medium and the gas in the space behind the impeller in the gaps between the rear vanes (11; 21; 31, 32; 52, 53) generated by the combined effect of radial forces, forces parallel to the rim of the impeller and inertial forces on the medium is established between a smallest and largest radial limit, the smallest radial limit being larger than the radius of the gas discharge duct and the larger radial limit being smaller than the radius of the impeller.

8. An apparatus according to claim 7, characterized in that the number $\underline{z}$ of rear vanes (11; 21; 31, 32; 52, 53) of the impeller (5) follows the formula

$z > 370 \cdot \sin\beta / n$, in which

β is the angle between the tangent of the impeller and the average direction of the rear vane, and $\underline{n}$ is the rotational speed of the impeller r/s.

9. An apparatus according to claim 7, characterized in that there are more rear vanes (11; 31, 32; 52, 53) than there are pumping vanes (6) on the front side of the impeller (5).

10. An apparatus according to claim 9, characterized in that the number of rear vanes (11; 31, 32; 52, 53) is at least double the number of actual pumping vanes (6), whereby the gas discharge openings (20) in the impeller (5) are

located, when seen from the rear side of the impeller, maximally in every other vane gap depending on the relation of the number of the rear vanes to the pumping vanes (6).

11. An apparatus according to claim 7, characterized in that the rear vanes (21; 31, 32; 52, 53) are inclined forwards or backwards.

12. An apparatus according to claim 11, characterized in that the rear vanes (21; 31, 32; 52, 53) are inclined from the outer edge substantially backwards relative to the rotational direction of the impeller (5) in such a way that the imaginary extension of the rear vanes is tangential to the central gas discharge duct (12) in the rear wall of the pump.

13. An apparatus according to claim 10, characterized in that the rear vane (32; 52) preceding the respective gas discharge opening (20) in the impeller (5) in the rotational direction of the impeller is shorter than the rear vane (31; 53) following said opening.

14. An apparatus according to claim 7, characterized in that a flow passage from one vane gap to another is arranged in the rear vanes of the impeller (5).

15. An apparatus according to claim 14, characterized in that the flow passage is formed as a perforation (56), a gap, a bevel, or a slot (57) in the rear vanes or as a flow passage arranged at the rear vanes substantially between the center of the pump and the gas discharge duct or a cut-out or a duct leading to an area of lower pressure.

16. An apparatus according to claim 7, characterized in that the inner end of the rear vanes (52) preceding the respective gas discharge openings (20) of impeller (5) in the rotational direction of the impeller are respectively arranged to follow the front and inner edge of the respective gas discharge opening (20) in shape, in other words hook-like.

17. An apparatus according to claim 7, characterized in that the cross-sectional flow area of a vane gap parallel to the rim of the impeller (5) is changed at some point with respect to its conventional form such that it is either uniform throughout the entire radial length of the vane gap, that it narrows in the radial direction towards the rim, or that the flow is throttled by arranging an extension of at least one rear vane parallel to the rim at the end of the rear vane, by arranging the rear vanes to be inclined in different directions or by arranging at least one local throttling point in said vane gap.

18. An apparatus according to claim 7, characterized in that a closing element (50; 51) is arranged at least between the discharge opening (3) of a volute (15) of the pump and the gas discharge duct (12), by which element fiber suspension is prevented from flowing to the gas discharge system.

19. An apparatus according to claim 18, characterized in that the closing element (50) is mounted in the housing of the pump outside rear vanes (11; 21; 31, 32; 52, 53) of impeller (5).

20. An apparatus according to claim 18, characterized in that the closing element (50) completely surrounds the rear vanes of the impeller (5), whereby openings are arranged in said closing element (50) for the discharge of fiber suspension from the rear side of the impeller (5) to the volute (15) of the pump.

21. An apparatus according to claim 18, characterized in that the closing element (51) comprises a protrusion arranged parallel to the discharge opening (3) of the volute (15) of the pump at the edge of the central gas discharge openings (12) in the rear wall of the pump, which protrusion closes at that point the gas discharge duct (12) which otherwise surrounds the shaft of the impeller (5).

22. An apparatus according to claim 7, characterized in that a vacuum pump is arranged in communication with the pump in the gas discharge system.

23. An apparatus in accordance with claim 22, characterized in that the vacuum pump is arranged on the same shaft as the impeller (5) of the pump or it is arranged to be run by a separate motor.

Patentansprüche

1. Verfahren zur Abscheidung von Gas aus einem gashaltigen Medium, das mittels einer Pumpe gepumpt wird, die ein Gehäuse, ein im Gehäuse angeordnetes und mit Förderschaufeln bestücktes Laufrad, Rückenschaufeln und ein Gasabzugssystem im Gehäuse umfaßt, aus folgenden Schritten bestehend:
- Abscheidung des Gases aus dem Medium auf der Vorderseite des Laufrads,

- Ableitung des abgeschiedenen Gases durch das Laufrad durch die Gasauslaßöffnungen zur Rückseite des Laufrads,
- Entfernung des möglicherweise mit dem Gas zur Rückseite des Laufrads geflossenen Mediums mit den Rückenschaufeln aus dem Gas, und
- Ableitung des Gases durch die Pumpe durch einen im Spiralgehäuse angeordneten Gasauslaßkanal, der zum Gasabzugssystem führt,

dadurch gekennzeichnet, daß

- die Grenzfläche zwischen Medium und Gas im Raum hinter dem Laufrad durch die kombinierte Wirkung von radialen Kräften, zum Umfang des Laufrads parallelen Kräften und Trägheitskräften zwischen einem kleinsten und größten radialen Grenzwert aufrechterhalten wird, welcher kleinste radiale Grenzwert größer ist als der Radius des Gasauslaßkanals und der größere radiale Grenzwert kleiner ist als der Radius des Laufrads.

2. Verfahren gemäß Anspruch 1, dadurch gekennzeichnet, daß die Strömung die Rückseite einer Rückenschaufel des Laufrads entlang durch die kombinierte Wirkung der Kräfte zur Laufradachse hin geleitet wird und erlaubt wird, daß die Strömung durch die Leitung der zum Umfang parallelen Kräftekomponente in eine der genannten Rückenschaufel in Umlaufrichtung des Laufrads vorhergehenden Schaufelzelle abfließt.

3. Verfahren gemäß Anspruch 1, dadurch gekennzeichnet, daß die durch die kombinierte Wirkung der Kräfte zu den Gasauslaßöffnungen des Laufrads entstandene Strömung von Medium zur Laufradachse hin geleitet wird und erlaubt wird, daß die Strömung durch die Gasauslaßöffnungen zur Vorderseite des Laufrad abfließt.

4. Verfahren gemäß Anspruch 1, dadurch gekennzeichnet, daß der Druck des Spiralgehäuses daran gehindert wird, in den Raum zu gelangen und auf das Medium einzuwirken, wenn der Druck des Spiralgehäuses nah an seinem Maximum steht, indem der Strömungspfad an der entsprechenden Stelle gedrosselt wird.

5. Verfahren gemäß Anspruch 1, dadurch gekennzeichnet, daß die Strömung des auf die Laufradachse zu fließenden Mediums, die durch die Druckspitze des Spiralgehäuses der Pumpe entstanden daran gehindert wird, in den Gasauslaßkanal zu gelangen, indem der zum Gasauslaßkanal führende Strömungspfad an der stelle des Spitzendrucks des Spiralgehäuses gedrosselt wird.

6. Verfahren gemäß Anspruch 1, dadurch gekennzeichnet, daß die Druckspitze des Spiralgehäuses der Pumpe in einer Schaufelzelle zwischen den Rückenschaufeln daran gehindert wird, das Medium in eine Richtung auf den Gasauslaßkanal hin zu beschleunigen, indem der Druckaustritt um die Kante einer der Schaufelzelle in Umlaufrichtung des Laufrads vorhergehenden Rückenschaufel herum oder durch eine Öffnung, einen Schlitz oder dergleichen in der vorhergehenden Rückenschaufel in eine gegenüber der genannten vorhergehenden Schaufelzelle benachbarte Schaufelzelle oder Schaufelzellen geleitet wird.

7. Vorrichtung zur Abscheidung von Gas aus einem mittels einer Pumpe zu pumpenden gashaltigen Medium, welche Pumpe ein Gehäuse (1) mit Saug- und Auslaßsöffnungen (2, 3), ein innerhalb des Gehäuses angeordnetes, mit Förderschaufeln (6) Rückenschaufeln und Gasauslaßöffnungen bestücktes Laufrad (5), eine Rückwand (8) der Pumpe, und aus einem Gasauslaßkanal (12) in der Rückwand (8) bestehende Mittel für den Abzug von Gas aus der Pumpe umfaßt, dadurch gekennzeichnet, daß, die Rückenschaufeln (11; 21; 31, 32; 52, 53) und die damit zusammen funktionierenden Organe auf solche Weise angeordnet sind, daß durch die vereinigte Wirkung von auf das Medium einwirkenden radialen Kräften, zum Umfang des Laufrads parallelen Kräften und Trägheitskräften im Raum hinter dem Laufrad in den Spalten zwischen den Rückenschaufeln (11; 21; 31, 32; 52, 53) eine Grenzfläche zwischen Medium und Gas entsteht zwischen einem kleinsten und größten radialen Grenzwert, wobei der kleinste radiale Grenzwert größer ist als der Radius des Gasauslaßkanals und der größere radiale Grenzwert kleiner ist als der Radius des Laufrads.

8. Vorrichtung gemäß Anspruch 7, dadurch gekennzeichnet, daß die Anzahl z Rückenschaufeln (11; 21; 31, 32; 52, 53) des Laufrads (5) der Formel

$z > 370 * \sin\beta / n$ entspricht, worin β der Winkel zwischen der Tangente des Laufrads und der durchschnittlichen Richtung der Rükkenschaufel, und n die Umlaufgeschwindigkeit des Laufrads U/s ist.

9. Vorrichtung gemäß Anspruch 7, dadurch gekennzeichnet, daß es der Rückenschaufeln (11; 31, 32; 52, 53) mehr gibt als Förderschaufeln (6) auf der Vorderseite des Laufrads (5).

10. Vorrichtung gemäß Anspruch 9, dadurch gekennzeichnet, daß die Anzahl Rückenschaufeln (11; 31, 32; 52, 53) zumindest zweifach gegenüber der Anzahl der eigentlichen Förderschaufeln (6) ist, wobei die Gasauslaßöffnungen (20) des Laufrads, auf die Rückseite des Laufrads gesehen, in Abhängigkeit vom Verhältnis der Anzahl Rückenschaufeln zu Förderschaufeln höchstens in jeder zweiten Schaufelzelle angeordnet sind.

11. Vorrichtung gemäß Anspruch 7, dadurch gekennzeichnet, daß die Rückenschaufeln (21; 31, 32; 52, 53) nach vorne oder hinten geneigt sind.

12. Vorrichtung gemäß Anspruch 11, dadurch gekennzeichnet, daß die Rückenschaufeln (21; 31, 32; 52, 53) gegenüber der Umlaufrichtung des Laufrads (5) an ihrer Außenkante hauptsächlich auf solche Weise nach hinten geneigt sind, daß die imaginäre Fortsetzung der Rükkenschaufeln den zentralen Gasauslaßkanal (12) in der Pumpenrückwand tangiert.

13. Vorrichtung gemäß Anspruch 10, dadurch gekennzeichnet, daß die der entsprechenden Gasauslaßöffnung (20) des Laufrads (5) vorangehende Rückenschaufel (32; 52) in der Umlaufrichtung des Laufrads kürzer ist als die der genannten Öffnung folgende Rückenschaufel (31; 53).

14. Vorrichtung gemäß Anspruch 7, dadurch gekennzeichnet, daß in den Rückenschaufeln des Laufrads (5) ein Strömungspfad von Schaufelzelle zu Schaufelzelle vorgesehen ist.

15. Vorrichtung gemäß Anspruch 14, dadurch gekennzeichnet, daß der Strömungspfad als Loch (56), Spalt, Anfasung, oder Schlitz (57) in den Rückenschaufeln oder als Strömungspfad an den Rückenschaufeln hauptsächlich zwischen dem Pumpenzentrum und dem Gasauslaßkanal oder als Vertiefung oder Kanal ausgebildet ist, die/der zu einem Bereich niedrigeren Drucks führt.

16. Vorrichtung gemäß Anspruch 7, dadurch gekennzeichnet, daß die innere Enden der den entsprechenden Gasauslaßöffnungen (20) des Laufrads (5) in Umlaufrichtung des Laufrads vorangehenden Rückenschaufeln (52) jeweils so angeordnet sind, daß sie den vorderen und inneren Rand der betreffenden Gasauslaßöffnung (20) in Form entsprechen, also hakenförmig sind.

17. Vorrichtung gemäß Anspruch 7, dadurch gekennzeichnet, daß die Querschnittsfläche der zum Umfang des Laufrads (5) parallelen Schaufelzelle gegenüber ihrer konventionellen Form an einer Stelle auf solche Weise geändert worden ist, daß sie entweder über die gesamte radiale Länge der Schaufelzelle gleich breit ist, sich in Radialrichtung zum Umfang hin verjüngt, oder daß die Strömung gedrosselt wird, indem an mindestens einer Rükkenschaufel eine zum Umfang parallele Verlängerung am Ende der Rückenschaufel angeordnet wird, indem die Rückenschaufeln in verschiedene Richtungen geneigt arrangiert werden, oder indem mindestens eine örtliche Drosselstelle in besagter Schaufelzelle angeordnet wird.

18. Vorrichtung gemäß Anspruch 7, dadurch gekennzeichnet, daß mindestens zwischen der Auslaßsöffnung (3) eines Spiralgehäuses (15) der Pumpe und dem Gasauslaßkanal (12) ein Sperrorgan (50; 51) angeordnet ist, durch welches Organ die Fasersuspension daran gehindert wird, zum Gasabzugssystem zu fließen.

19. Vorrichtung gemäß Anspruch 18, dadurch gekennzeichnet, daß das Sperrorgan (50) im Pumpengehäuse außerhalb der Rückenschaufeln (11; 21; 31, 32; 52, 53) des Laufrads (5) angebracht ist.

20. Vorrichtung gemäß Anspruch 18, dadurch gekennzeichnet, daß das Sperrorgan (50) die Rückenschaufeln des Laufrads (5) vollständig umgibt, wobei in besagtem Sperrorgan (50) Öffnungen für den Auslaß von Fasersuspension von der Rückseite des Laufrads (5) zum Spiralgehäuse (15) angeordnet sind.

21. Vorrichtung gemäß Anspruch 18, dadurch gekennzeichnet, daß das Sperrorgan (51) aus einem zur Auslaßsöffnung (3) des Spiralgehäuses (15) der Pumpe parallelen am Rand der zentralen Gasauslaßöffnungen (12) in der Pumpenrückwand angeordneten Vorsprung besteht, welcher Vorsprung an jener Stelle den Gasauslaßkanal (12) umschließt, mit anderen Worten die Welle des Laufrads (5) umschließt.

22. Vorrichtung gemäß Anspruch 7, dadurch gekennzeichnet, daß im Gasabzugssystem in Verbindung mit der Pumpe eine Vakuumpum-

pe angeordnet ist.

23. Vorrichtung gemäß Anspruch 22, dadurch gekennzeichnet, daß die Vakuumpumpe auf der gleichen Welle wie das Laufrad (5) der Pumpe oder so arrangiert ist, daß sie von einem gentrennten Motor angetrieben wird.

Revendications

1. Procédé pour séparer un gaz d'un milieu contenant du gaz qui est pompé à l'aide d'une pompe qui comprend un logement, une hélice disposée dans le logement et comportant des ailettes de pompage, des ailettes postérieures et des orifices d'évacuation de gaz, et un système d'évacuation de gaz dans le logement, comprenant les étapes consistant à :
   - séparer le gaz du milieu sur le côté frontal de l'hélice
   - évacuer le gaz séparé à travers l'hélice par l'intermédiaire des orifices d'évacuation de gaz vers le gaz vers le côté postérieur de l'hélice
   - évacuer du gaz le milieu qui a éventuellement été transporté avec le gaz vers le côté postérieur de l'hélice, au moyen des ailettes postérieures.
   - évacuer le gaz de la pompe via une conduite d'évacuation de gaz dans le logement conduisant au système d'évacuation de gaz,

   caractérisé par le fait que l'on crée une interface entre le milieu et le gaz dans l'espace derrière l'hélice générée par l'effet combiné de forces radiales, de forces parallèles à la périphérie de l'hélice et de forces d'inertie entre la limite radiale minimale et maximale, la limite radiale minimale étant plus importante que le rayon de la conduite d'évacuation de gaz et la limite radiale la plus grande étant plus petite que le rayon de l'hélice.

2. Procédé selon la revendication 1, caractérisé par le fait que l'on dirige le flux le long de la surface arrière d'une ailette postérieure de l'hélice vers l'axe de l'hélice au moyen d'un effet combiné des forces et on permet au flux d'être évacué dans un intervalle d'ailettes précédant l'ailette postérieure dans la direction de rotation de l'hélice par le guidage de la composante de force qui est parallèle à la périphérie.

3. Procédé selon la revendication 1, caractérisé par le fait que l'on dirige l'écoulement du milieu s'écoulant vers l'axe de l'hélice au moyen d'un effet combiné des forces, vers les orifices d'évacuation de gaz dans l'hélice, et on permet au flux d'être évacué vers le côté frontal de l'hélice à travers les orifices d'évacuation de gaz.

4. Procédé selon la revendication 1, caractérisé par le fait que l'on empêche la pression d'une volute de la pompe de pénétrer dans l'espace et on agit sur le milieu lorsque la pression de la volute est à un point proche de son maximum, en étranglant le passage d'écoulement au point correspondant

5. Procédé selon la revendication 1, caractérisé par le fait qu'on empêche l'entrée dans la conduite d'évacuation de gaz, du flux du milieu circulant vers l'axe de l'hélice et généré par la pointe de pression d'une volute de la pompe en étranglant le passage d'écoulement conduisant à la conduite d'évacuation de gaz à l'endroit de la pointe de pression de la volute.

6. Procédé selon la revendication 1, caractérisé par le fait que l'on empêche la pointe de pression d'une volute de la pompe dans un intervalle d'ailettes entre les ailettes postérieures d'accélérer le milieu dans une direction vers la conduite d'évacuation de gaz en dirigeant l'évacuation de la pression autour du bord d'une ailette postérieure précédant l'intervalle d'ailettes dans la direction de rotation de l'hélice ou via un orifice, une fente ou analogue dans l'ailette postérieure précédente dans un ou des intervalles d'ailettes près dudit intervalle précédent.

7. Dispositif pour séparer un gaz d'un milieu contenant du gaz pompé par une pompe, laquelle comprend un logement (1) avec des orifices d'aspiration et d'évacuation (2,3), une hélice (5) disposée à l'intérieur du logement et munie d'ailettes de pompage (6), d'ailettes postérieures et d'orifices d'évacuation de gaz, une paroi postérieure (8) de la pompe, et des moyens pour l'évacuation du gaz de la pompe comprenant une conduite d'évacuation de gaz (12) dans la paroi postérieure (8) caractérisé en ce que les ailettes postérieures (11; 21; 31; 32; 52; 53), et les éléments fonctionnant ensemble avec celles-ci sont disposés de façon à établir une interface entre le milieu et le gaz dans l'espace derrière l'hélice dans les intervalles entre les ailettes postérieures (11; 21; 31; 32; 52; 53), générée par l'effet combiné de forces radiales, de forces parallèles à la périphérie de l'hélice et de forces d'inertie sur le milieu, entre des limites radiales minimale et maximale, la limite radiale la plus petite étant

plus importante que le rayon de la conduite d'évacuation de gaz et la limite radiale la plus grande étant plus petite que le rayon de l'hélice.

8. Dispositif selon la revendication 7, caractérisé en ce que le nombre z d'ailettes postérieures (11; 21; 31; 32; 52; 53) de l'hélice (5) suit la formule

$z > 370 * \sin\beta / n$, dans laquelle

β est l'angle entre la tangente de l'hélice et la direction moyenne de l'ailette postérieure, et n est la vitesse de rotation de l'hélise r/s.

9. Dispositif selon la revendication 7, caractérisé en ce qu'il y a plus d'ailettes postérieures (11; 31; 32; 52; 53) que d'ailettes de pompage (6) sur le côté frontal de l'hélice.

10. Dispositif selon la revendication 9, caractérisé en ce que le nombre d'ailettes postérieures (11; 31; 32; 52; 53) est au moins le double du nombre d'ailettes de pompage effectives (6), de manière que les orifices d'évacuation de gaz (20) dans l'hélice soient situés, vu du côté arrière de l'hélice dans un intervalle d'ailettes sur deux au maximum en fonction d'ailettes postérieures par rapport aux ailettes de pompage.

11. Dispositif selon la revendication 7, caractérisé en ce que les ailettes postérieures (21; 31; 32; 52; 53) sont inclinées en avant ou en arrière.

12. Dispositif selon la revendication 11, caractérisé en ce que les ailettes postérieures (21; 31; 32; 52; 53) sont inclinées à partir du bord extérieur sensiblement en arrière par rapport à la direction de rotation de l'hélice (5) de manière que l'extension imaginaire d'ailettes postérieures soit tangentielle à la conduite centrale d'évacuation de gaz (12) dans la paroi postérieure de la pompe.

13. Dispositif selon la revendication 10, caractérisé en ce que l'ailette postérieure (32; 52) précédant l'orifice d'évacuation de gaz respectif (20) dans l'hélice (5) dans la direction de rotation de l'hélice est plus courte que l'ailette postérieure (31; 53) suivant ledit orifice.

14. Dispositif selon la revendication 7, caractérisé en ce qu'un passage d'écoulement d'un intervalle d'ailettes à l'autre est disposé dans les ailettes postérieures de l'hélice (5).

15. Dispositif selon la revendication 14, caractérisé en ce que le passage d'écoulement est formé comme une perforation (56), un intervalle, une facette, ou une lente (57) dans les ailettes postérieures ou comme un passage d'écoulement disposé sur les ailettes postérieures entre le centre de la pompe et la conduite d'évacuation de gaz ou une découpe ou une conduite menant à la zone de pression inférieure.

16. Dispositif selon la revendication 7, caractérisé en ce que l'extrémité intérieure des ailettes postérieures précédant les orifices d'évacuation de gaz respectifs (20) de l'hélice (5) dans la direction de rotation de l'hélice est disposée respectivement de façon à suivre la forme du bord intérieur et frontal de l'orifice d'évacuation de gaz respectif (20), en d'autres termes, elle est recourbée en crochet.

17. Dispositif selon la revendication 7, caractérisé en ce que la section droite d'écoulement d'un intervalle d'ailettes parallèle à la périphérie de l'hélice (5) est modifiée en un certain endroit en ce qui concerne sa forme classique de façon qu'elle soit uniforme sur toutes la longueur radiale de l'intervalle d'ailettes afin qu'elle devienne plus étroite dans la direction radiale vers la périphérie, ou que l'écoulement soit étranglé en disposant une extension d'au moins une ailette postérieure parallèle à la périphérie à l'extrémité de l'ailette postérieure, en disposant les ailettes postérieures de façon qu'elles soient inclinées dans des directions différentes ou en disposant au moins un point local d'étranglement dans ledit intervalle d'ailettes.

18. Dispositif selon la revendication 7, caractérisé en ce qu'un élément de fermeture (50 ; 51) est disposé au moins entre l'orifice d'évacuation (3) d'une volute (15) de la pompe et la conduite d'évacuation de gaz (12), élément par lequel on empêche que la suspension de fibres s'écoule vers le système d'évacuation de gaz.

19. Dispositif selon la revendication 18, caractérisé en ce que l'élément de fermeture (50) est monté dans le logement de la pompe à l'extérieur des ailettes postérieures (11; 21; 31; 32; 52; 53) de l'hélice (5).

20. Dispositif selon la revendication 18, caractérisé en ce que l'élément de fermeture (50) entoure complètement les ailettes postérieures de l'hélice (5), de façon que les orifices soient disposés dans ledit élément de fermeture (50) pour l'évacuation de la suspension de fibres du côté

arrière de l'hélice (5) vers la volute (15) de la pompe.

21. Dispositif selon la revendication 18, caractérisé en ce que l'élément de fermeture (51) présente une saillie disposée parallèlement à l'orifice d'évacuation (3) de la volute (15) de la pompe au bord des orifices d'évacuation centraux de gaz (12) dans la paroi postérieure de la pompe, ladite saillie fermant à cet endroit la conduite d'évacuation de gaz (12) qui autrement entoure l'arbre de l'hélice (5).

22. Dispositif selon la revendication 7, caractérisé en ce qu'une pompe à vide est disposée en communication avec la pompe dans le système d'évacuation de gaz.

23. Dispositif selon la revendication 22, caractérisé en ce que la pompe à vide est disposée sur le même arbre que l'hélice (5) de la pompe ou bien celle-ci est disposée de façon à être entrainée par un moteur séparé.

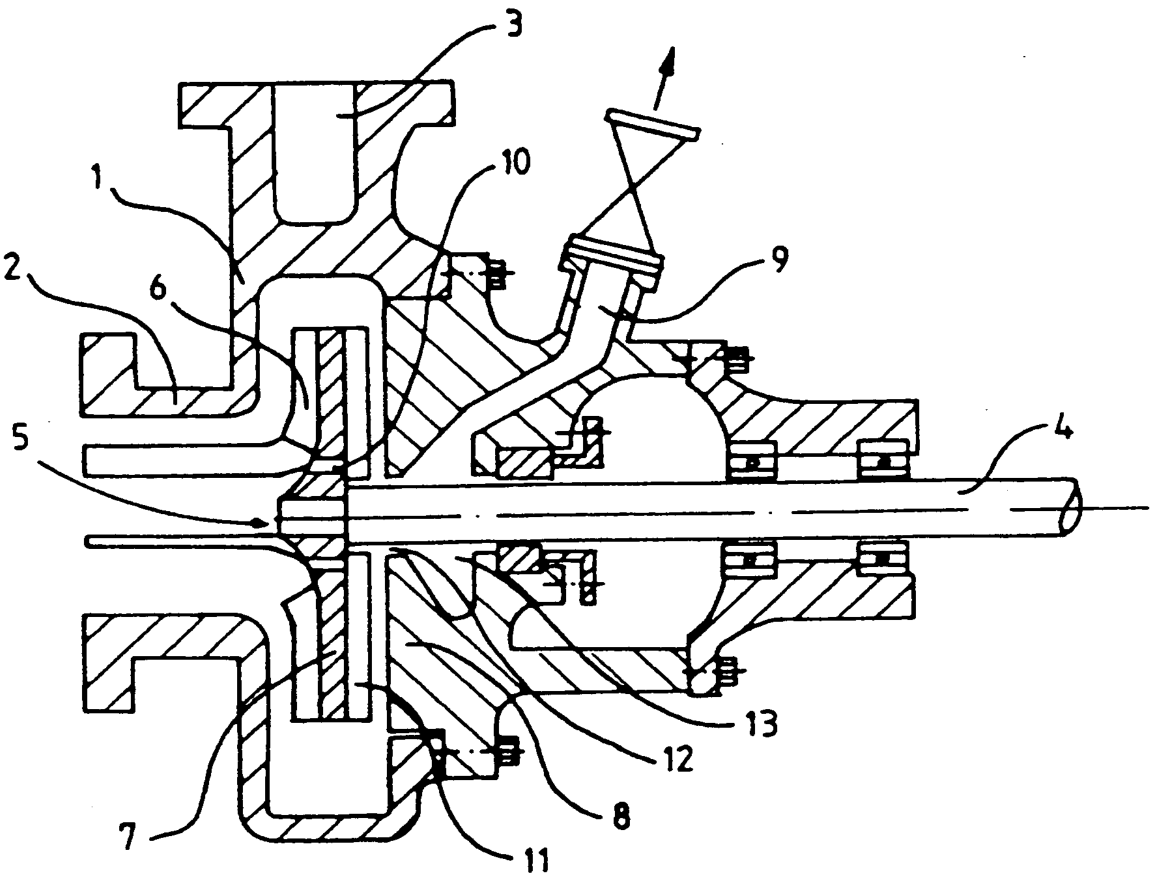

FIG. 1

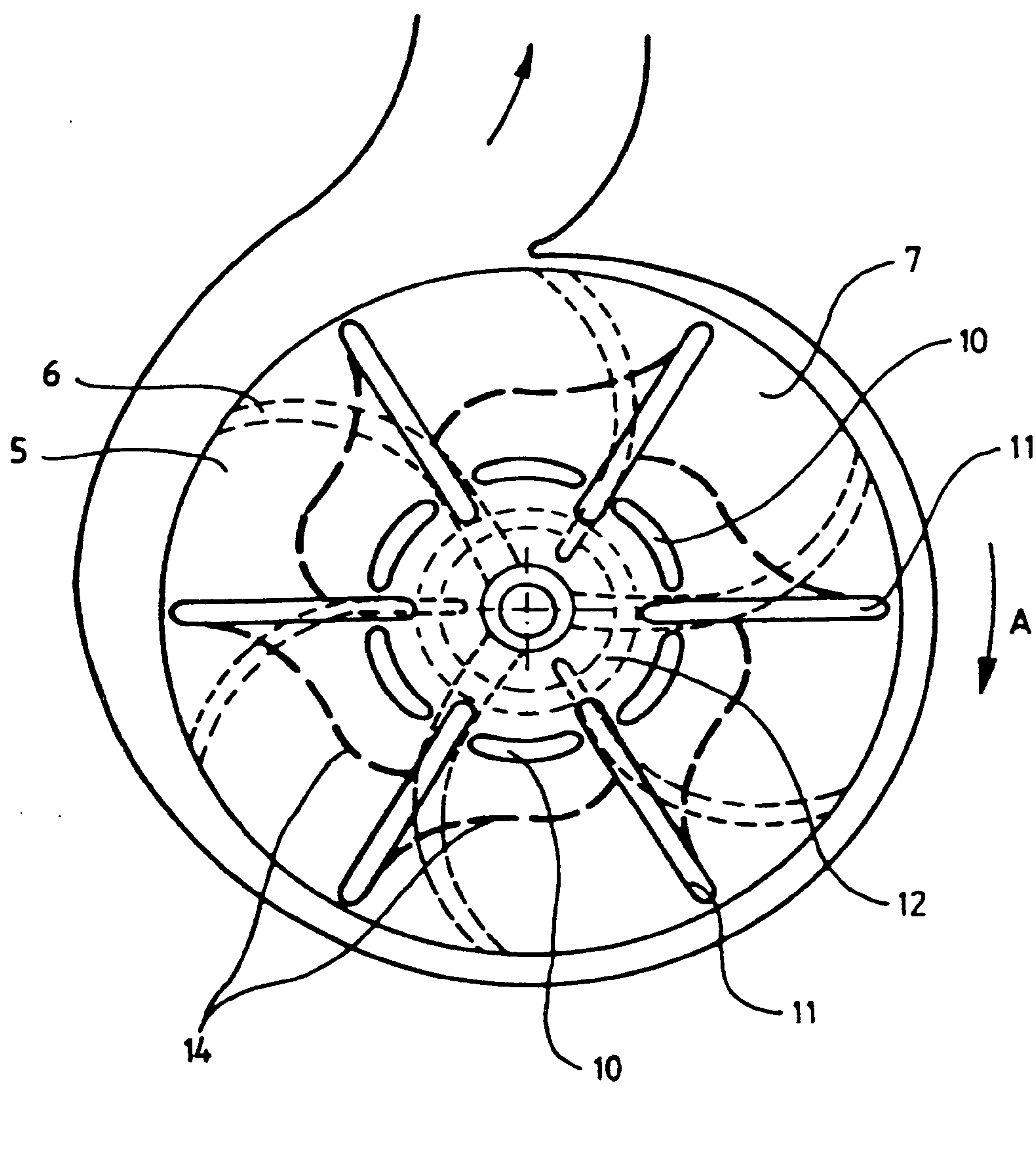

FIG. 2

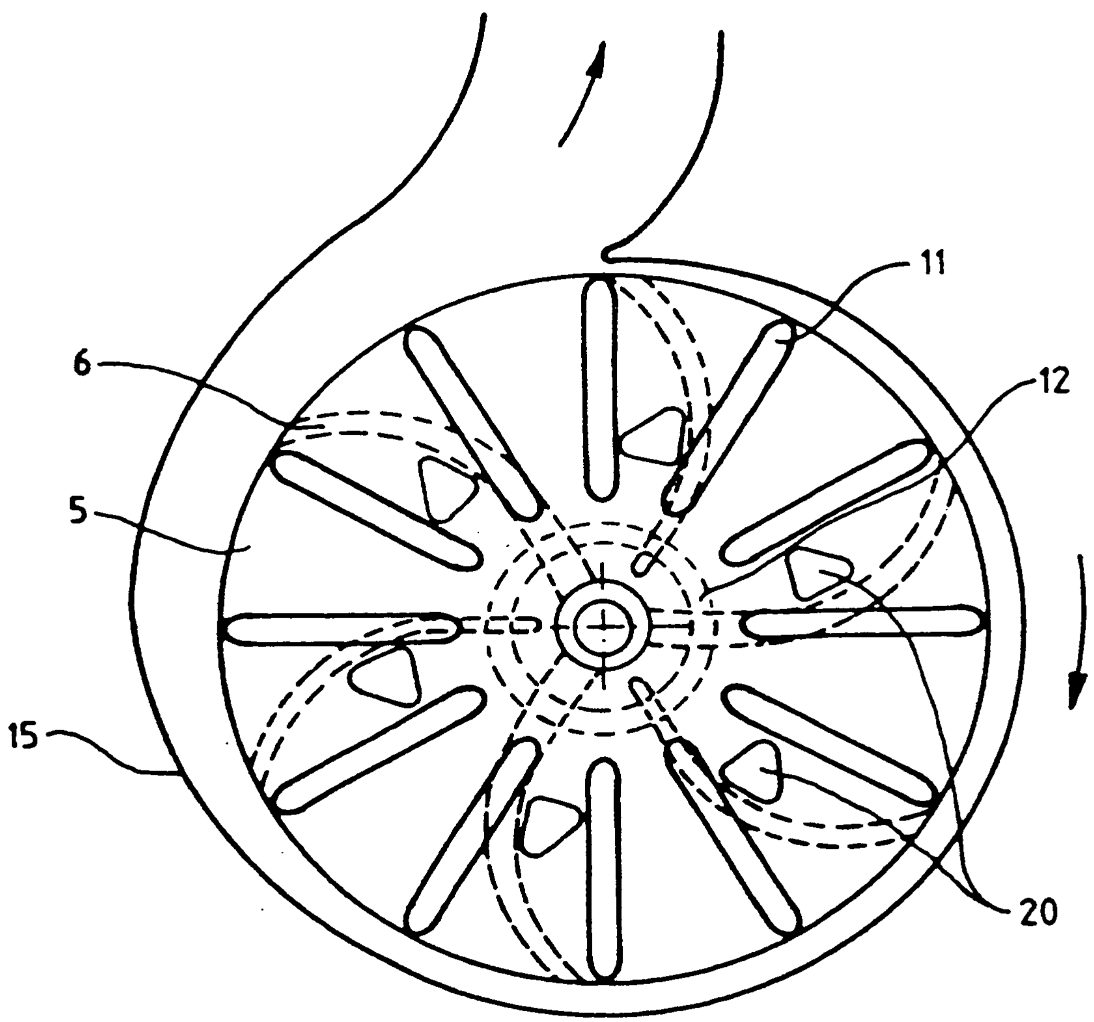

FIG. 3

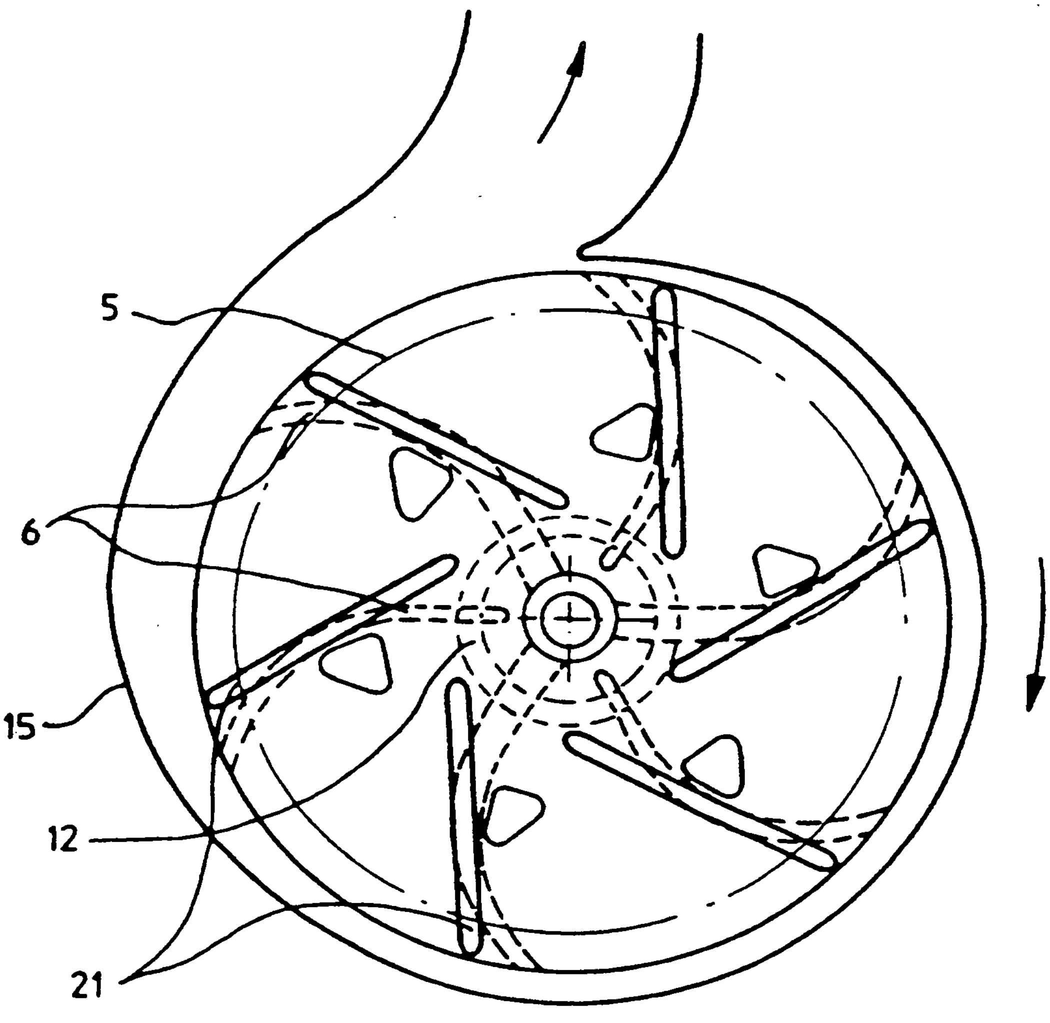

FIG. 4

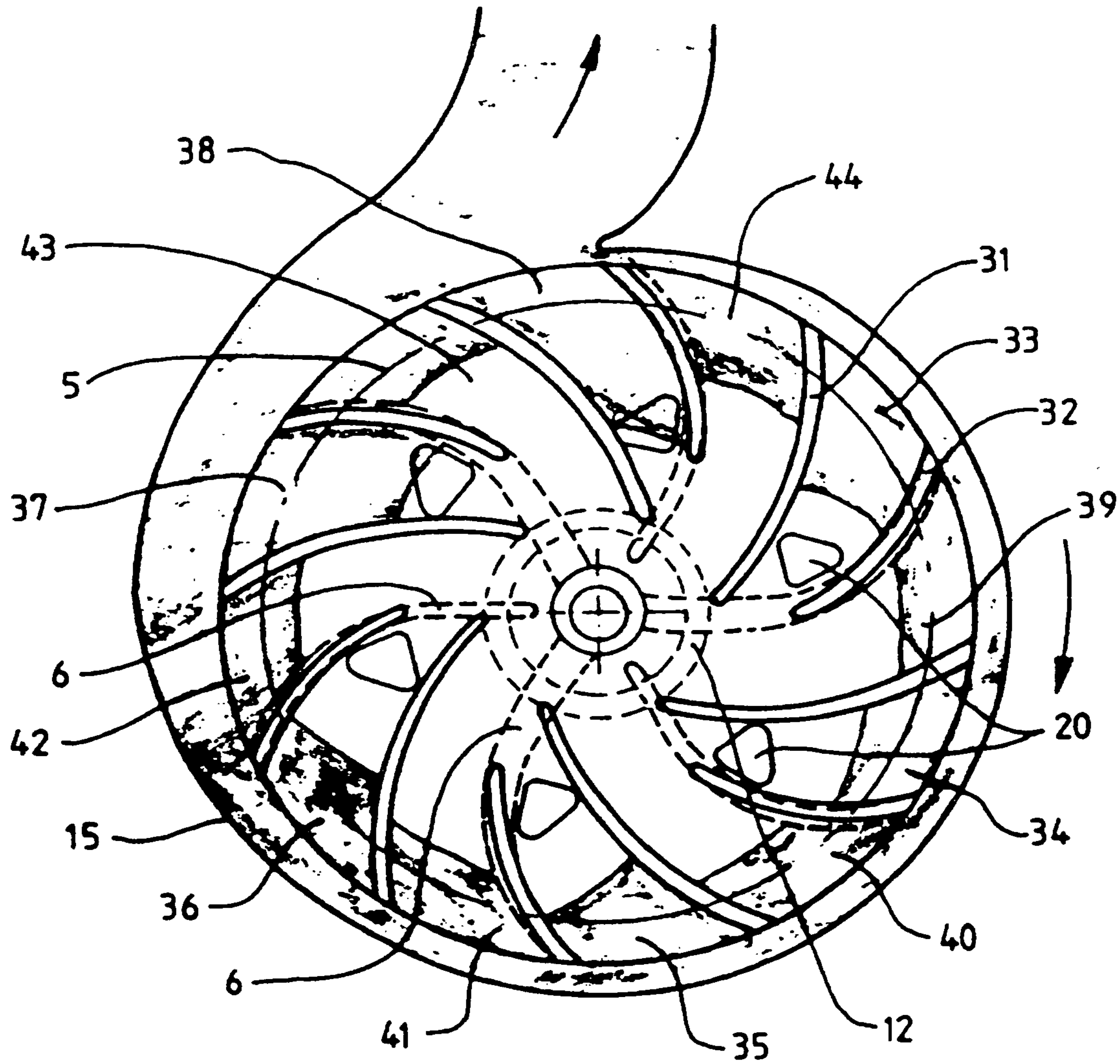

FIG. 5

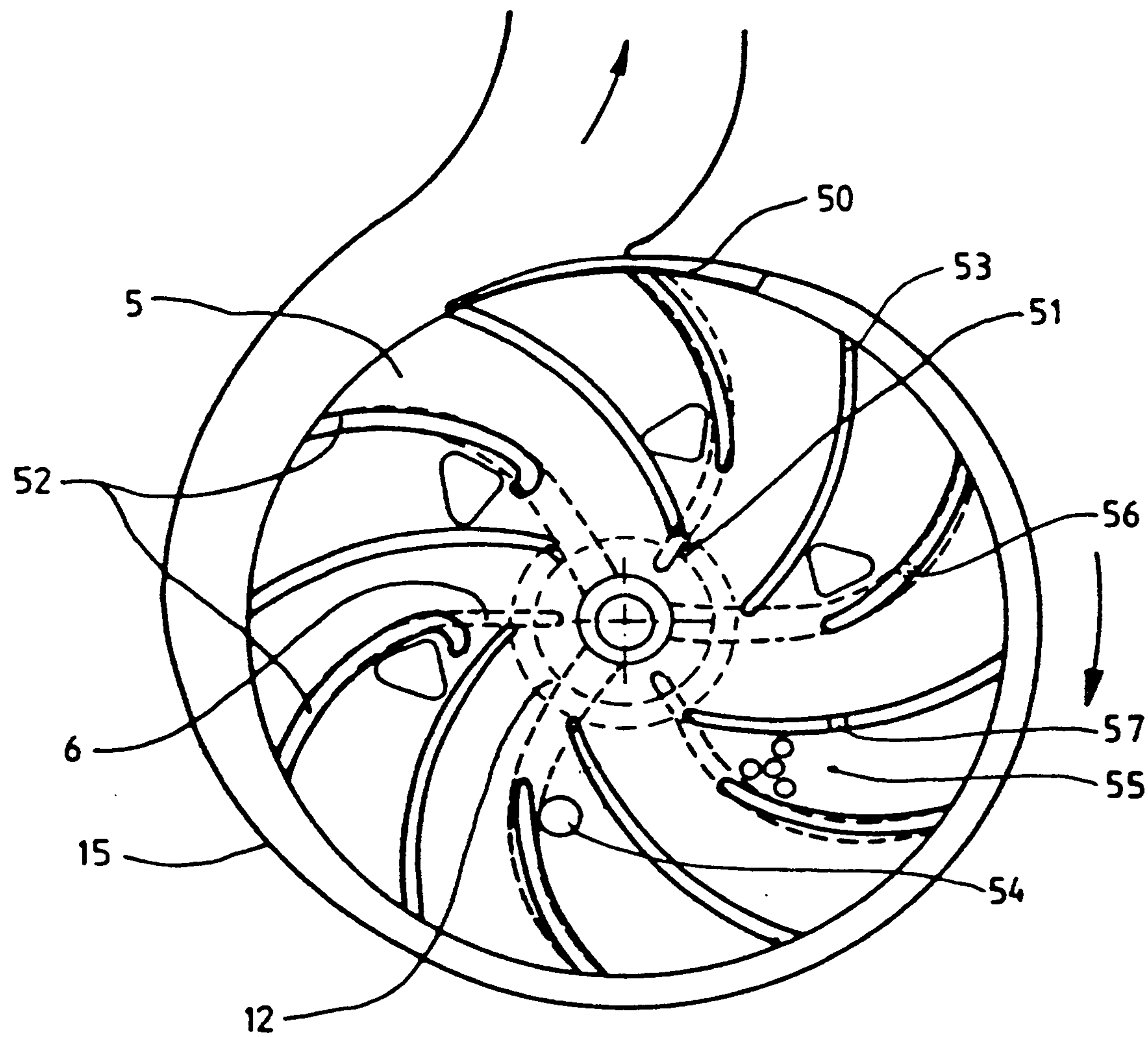

FIG. 6

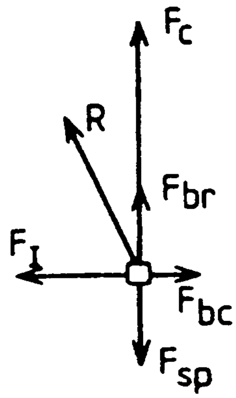

FIG. 7a

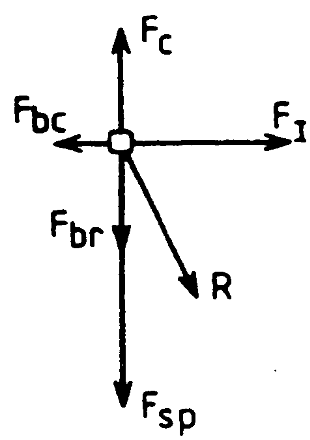

FIG. 7b